# Potential Impacts of Climate Change on Residential Wildfire Risk in California

Anthony Westerling* and Benjamin Bryant**

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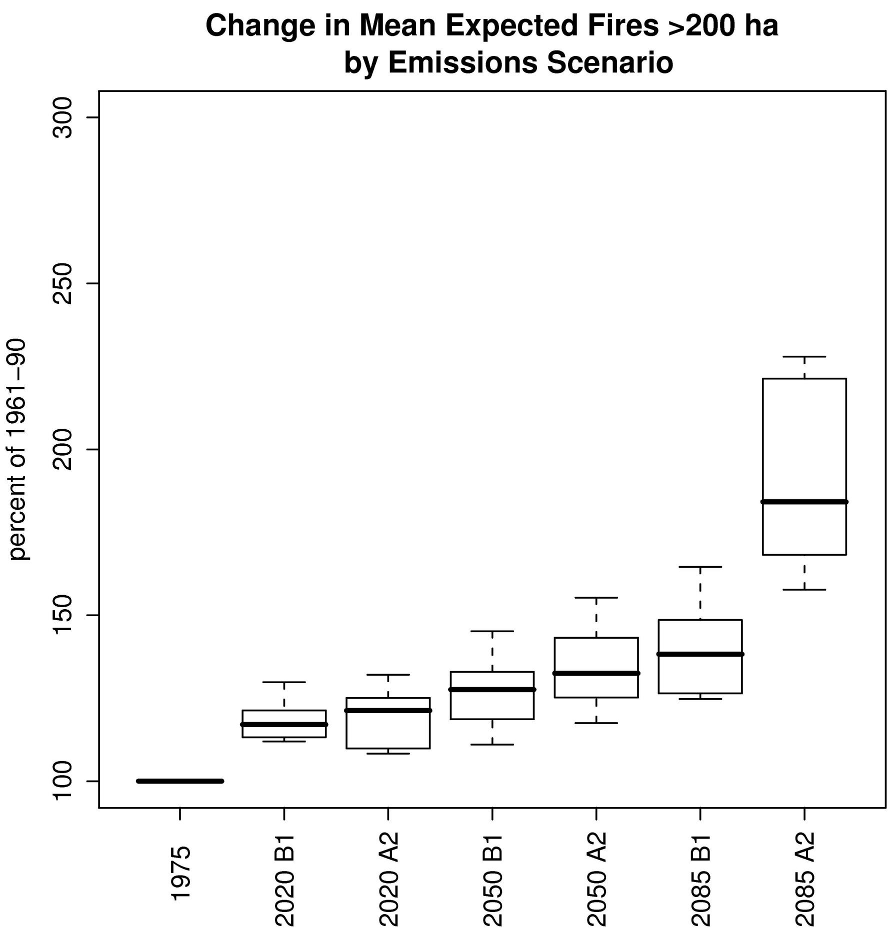
*Sierra Nevada Research Institute
University of California, Merced

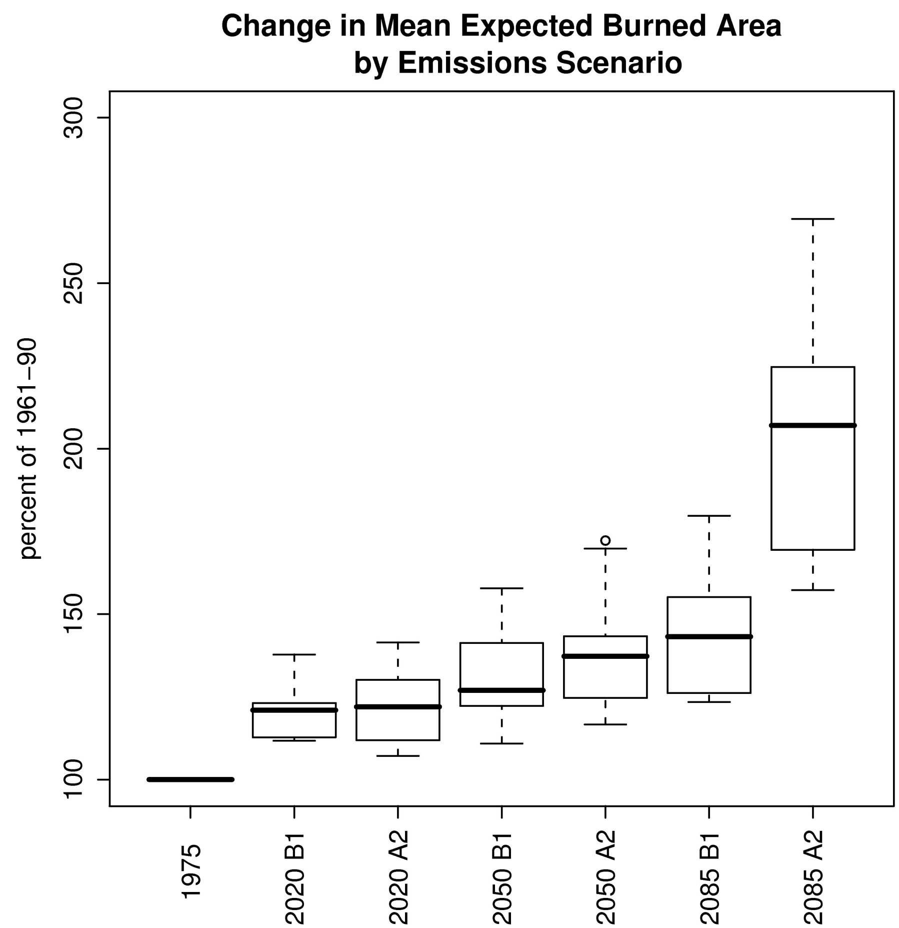
*Pardee RAND Graduate School
The RAND Corporation, Santa Monica

# Outline

- Short review of climate impacts on wildfire
- Discussion of residential development scenario
- Methodology for interacting wildfire risk and residential development
- Implications for residential wildfire risk
  - relative risk
  - cost implications

# Climate Change Is Expected to Exacerbate Large Wildfires in California




From: Westerling et al, 2009

# Changes in wildfire risk vary significantly across the state

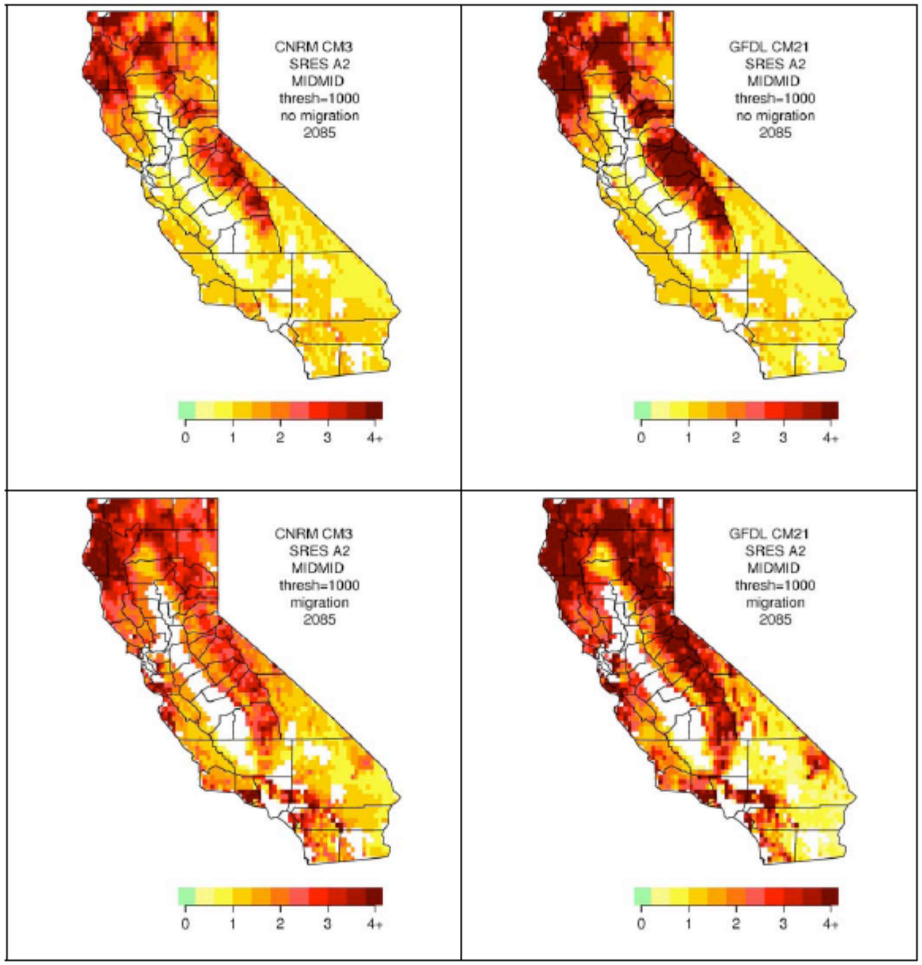



Figure 7. 2085 Predicted burned area as a multiple of reference period predicted area burned. Top panels show SRES A2 scenarios with the location of fire regimes fixed, while bottom panels simulate fire regimes (and ecosystems) shifting in response to changes in climate. All four scenarios show large increases in burned area in forests of the Sierra Nevada, northern California Coast, and southern Cascade ranges. With migration of fire regime types, burned area increases in coastal southern California and the Monterey Bay area. A value of "1" indicates burned area is unchanged, while 4+ indicates that burned area is 400% or more of the reference period.

- Different models lead to some differences in magnitude of impacts
- But spatial variation always significant
- We consider impacts of different models in our analysis

From: Westerling et al, 2009

# How Will Changing Fire Patterns Impact Risk To Humans?

- Impacts of Changing Wildfire Regimes

| Direct Human Impacts | Indirect Impacts |
|---|---|
| Structures burned/property value lost | Watersheds - soil loss, deposits |
| Suppression expenditures | Timber loss |
| Evacuation costs/lost productivity | Habitat disruption |
| Lives lost and adverse health effects of smoke | Species loss |
| Diminished recreational opportunities and viewsheds | Non-native species invasion |
| Disruption to infrastructure availability | |

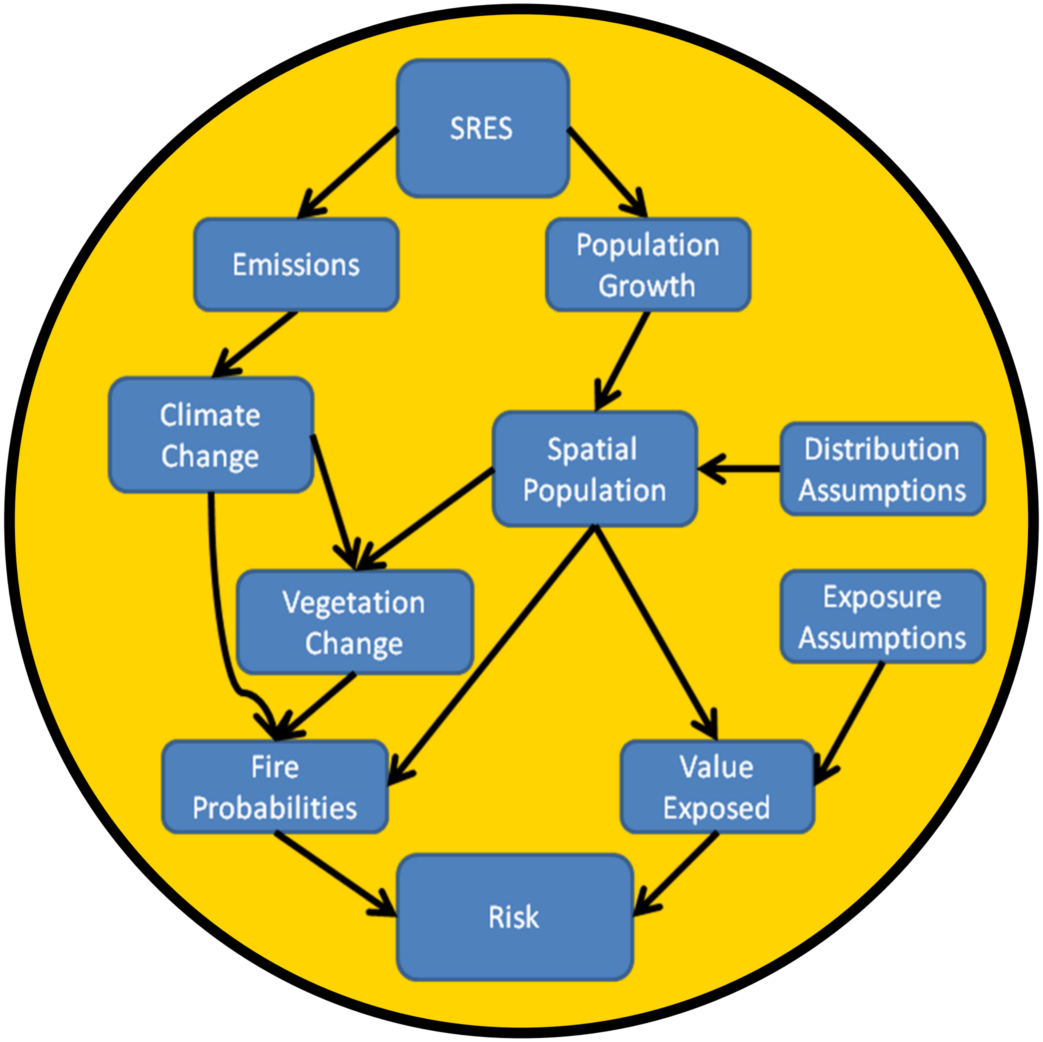
- Here we focus only on risk to homes
  - This requires estimate of how homes are distributed across CA during the 21st century

# ICLUS scenarios from EPA provide spatially explicit housing trajectories

- **I**ntegrated **C**limate and **L**and **U**se **S**cenarios (Theobald) provide housing density projections at the 100 meter level

- ICLUS project developed data for multiple SRES scenarios (A2, B1 etc), though only the baseline scenario was available at time of analysis.

# We generate risk to homes by interacting fire risk and growth patterns



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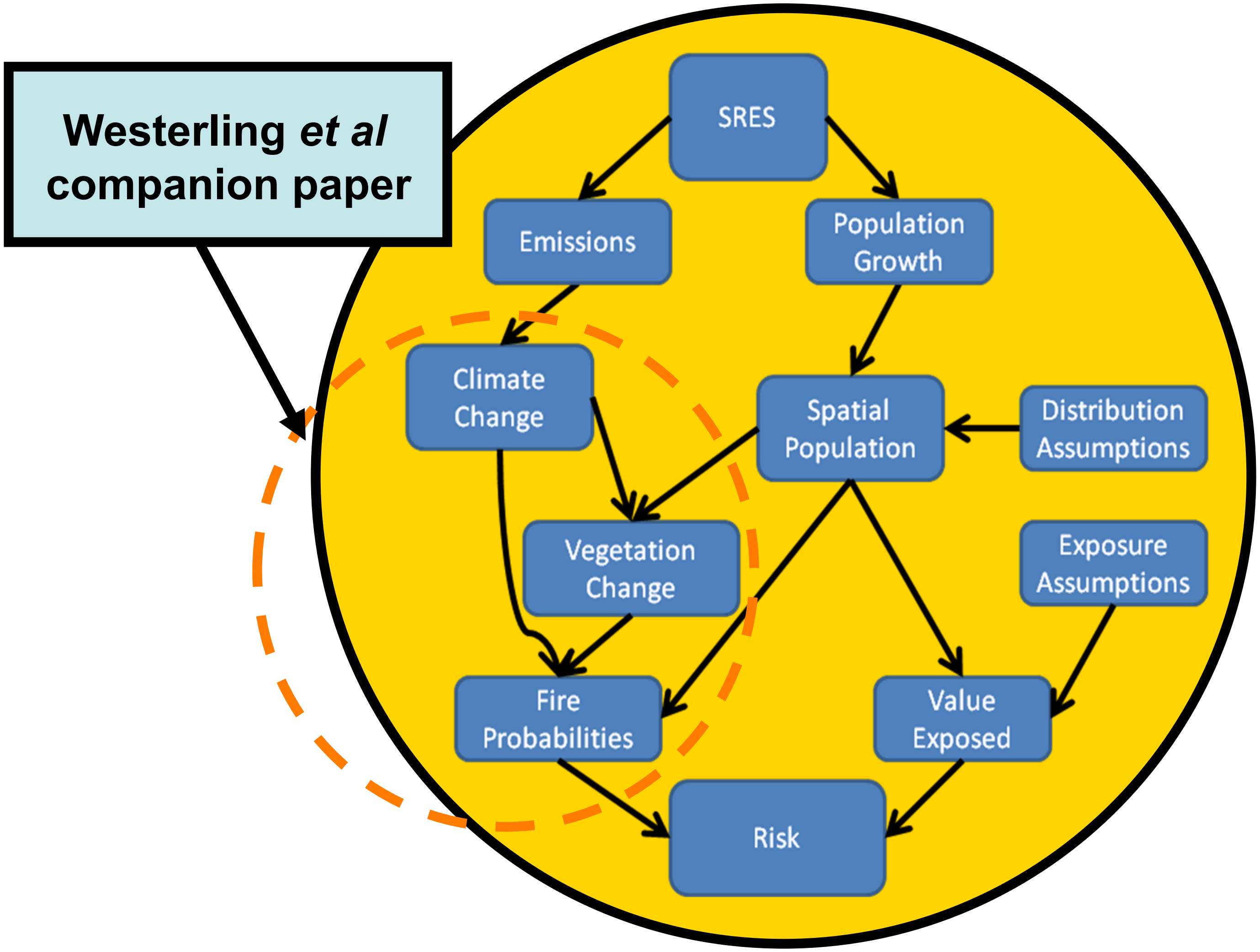

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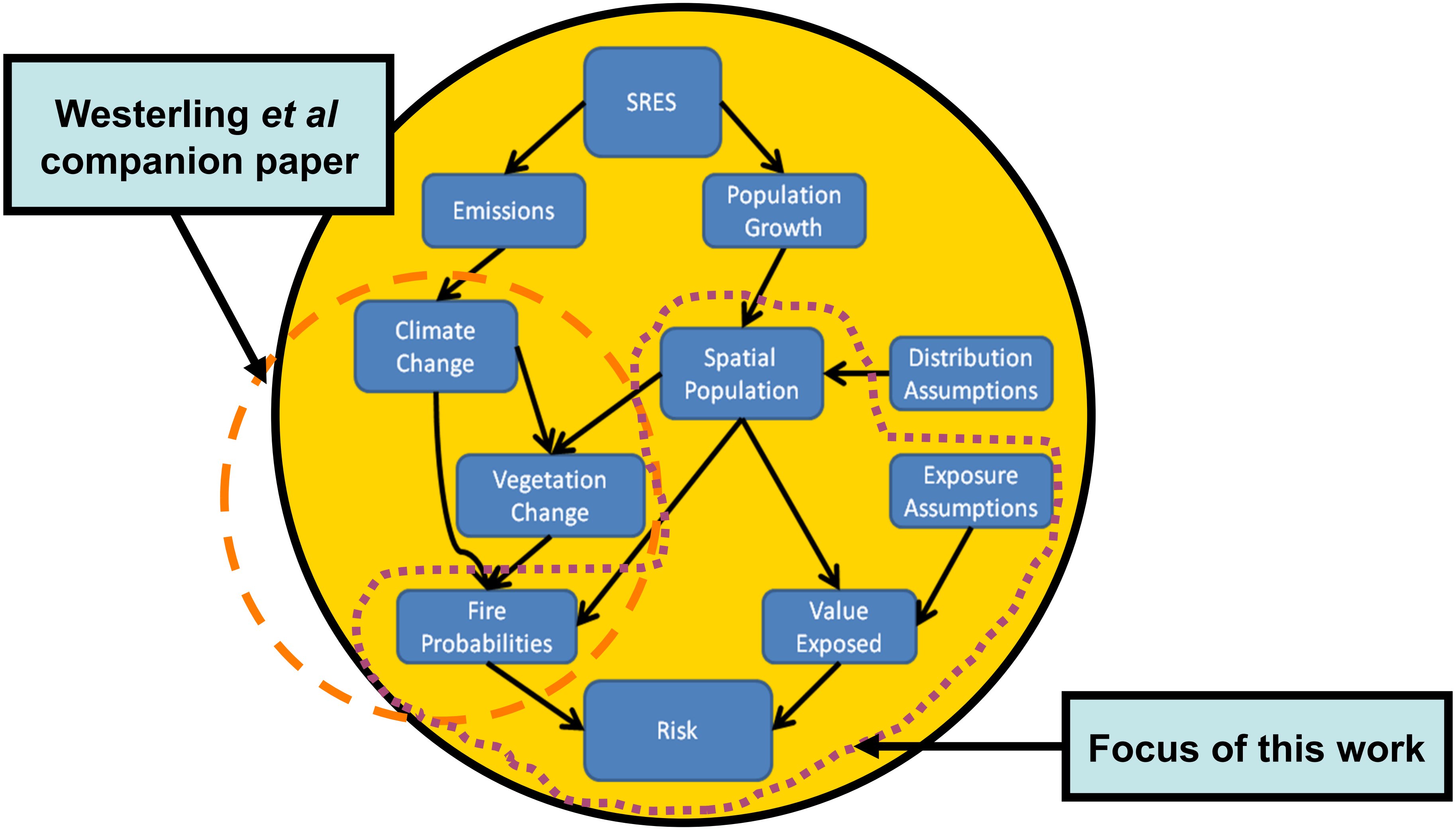


# Our Risk Model Begins With Pure Expected Value and Makes Several Approximations

To start:

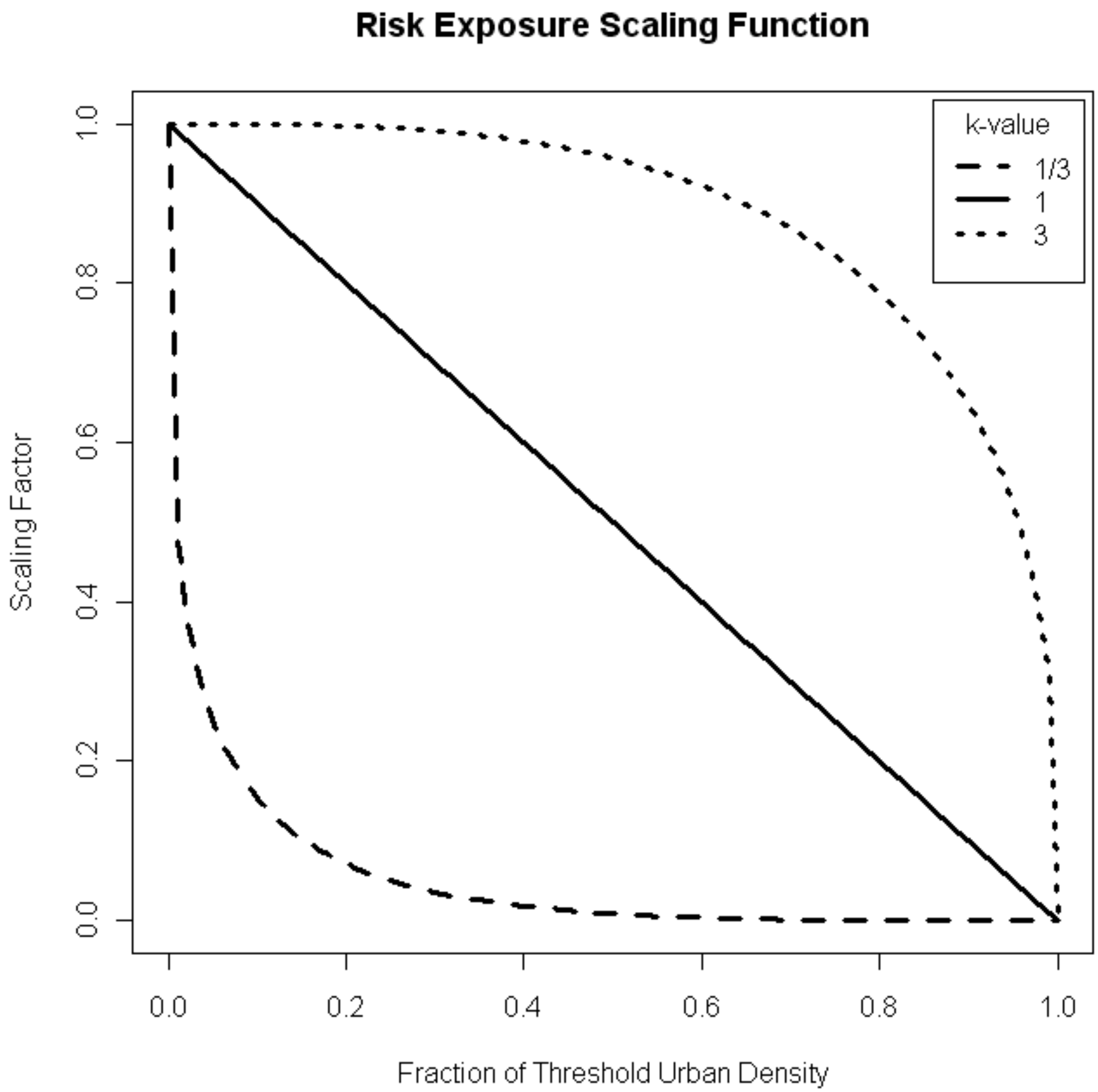
*RISK = P(FIRE) * E( VALUE LOST | FIRE )*

Problems:

- Spatial scale mismatch:
  P(home within fire perimeter) not the same as
  P(fire within gridcell)
- Fire dynamics and spatial scale mismatch:
  E( VALUE LOST | FIRE ) not the same as value within fire perimeter

# Simplifying Assumptions

- Assume uniform distribution of fire risk across gridcell
- Postulate a statistical relationship between housing density and exposure
  - Accounts for limiting cases and also likely increase in protective action with value threatened
  - Varying shape of exposure function lets us consider wide range of possible behaviors


Risk Exposure Scaling Function
k-value
1/3
1
3
Scaling Factor
0.0
0.2
0.4
0.6
0.8
1.0
Fraction of Threshold Urban Density

# Our model

$$RISK_{gc} = p(C_{gc}, P_{gc}, V(H_{pix \subset gc})) \times E(A)_{gc} \times \sum_{pix \subset gc} X(H_{pix} s(H_{pix}))$$

p: probability of a large fire in gridcell

C: climate,

P: population

V: Vegetation

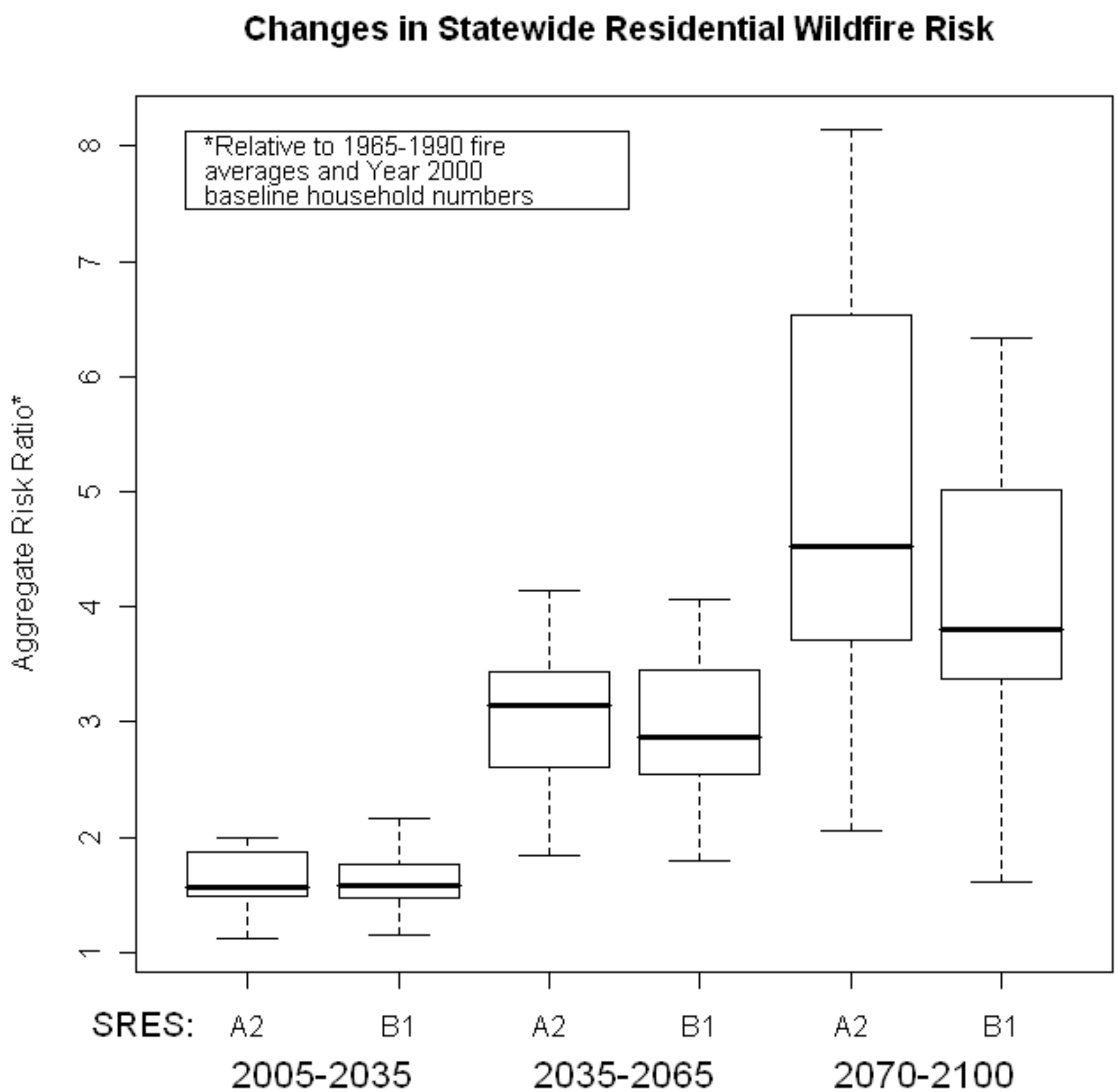
H: Homes

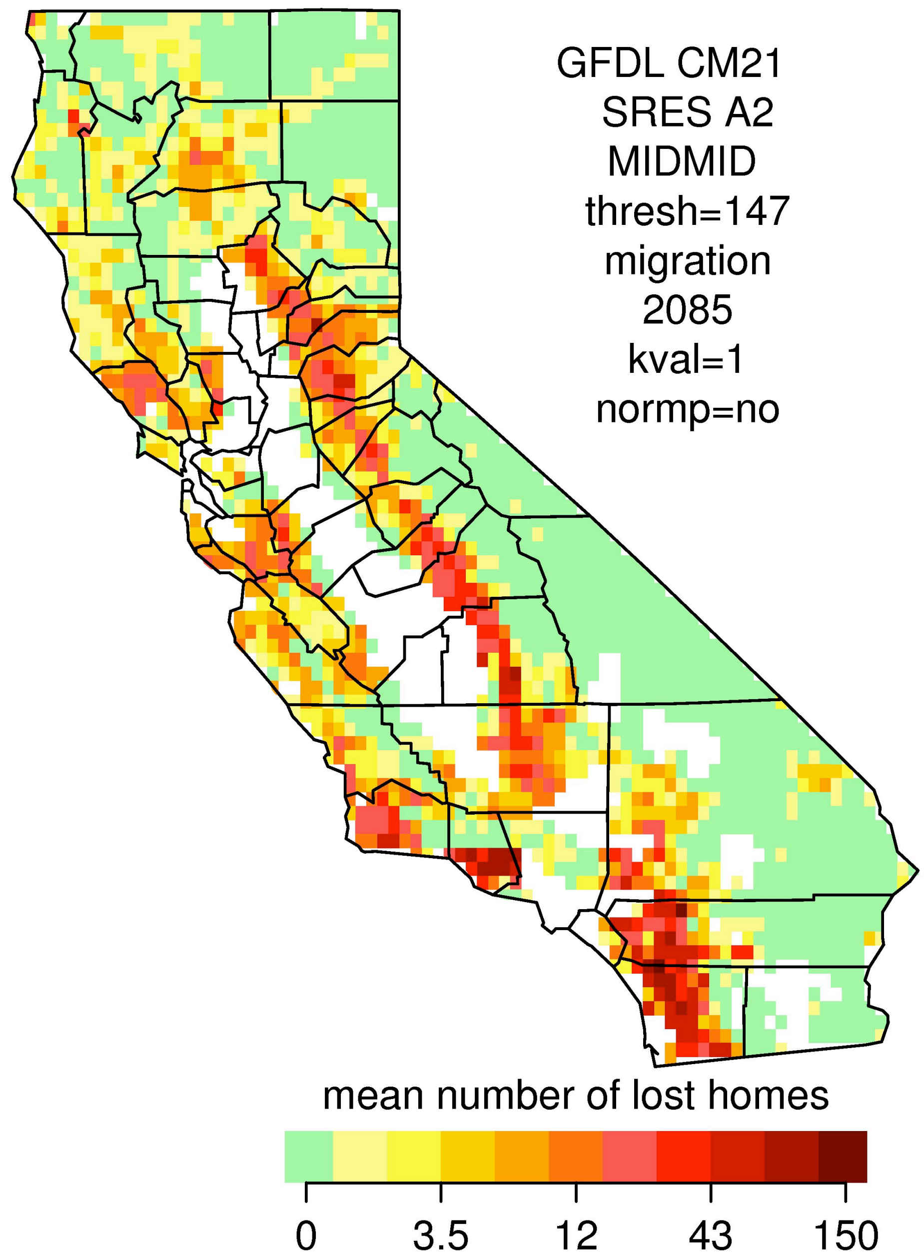
X = exposed home value

s = scaling function

$E(A)_{gc}$ = expected fraction of gridcell burned given fire

# Primary Results:
# Aggregate (Statewide) Relative Risk




GFDL CM21
SRES A2
MIDMID
thresh=147
migration
2085
kval=1
normp=no
mean number of lost homes
0
3.5
12
43
150

# Monetary impacts could easily be in the billions of dollars

**Summary Statistics for Aggregate Example Damages**

| | 2005-2035 | | | 2035-2065 | | | 2070-2100 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Upper | Max | Min | Upper | Max | Min | Upper | Max |
| SRES A2 | 0.050 | 0.48 | 2.4 | 0.20 | 2.3 | 13 | 0.68 | 14 | 80 |
| SRES B1 | 0.047 | 0.45 | 2.6 | 0.21 | 2.5 | 13 | 0.53 | 11 | 62 |

Figures are in billions of undiscounted Year 2000 dollars and represent possible monetary impacts in a representative year during each period.

- True under both climate scenarios,
  - though damages are estimated to be 25-30 percent higher under A2 by the end of century

# Caveats and Conclusions

- Will include A2/B1 growth scenarios
- Consider uncertainties more broadly

- Main relative risk conclusion
- Main spatial conclusion
- Main monetary conclusion

# References

- Current “Draft Final” White Papers:
  Westerling et al 2009:
  http://www.energy.ca.gov/2009publications/CEC-500-2009-046/CEC-500-2009-046-D.PDF
  Bryant and Westerling 2009:
  http://www.energy.ca.gov/2009publications/CEC-500-2009-048/CEC-500-2009-048-D.PDF
- 2006 Assessment Product:
  Westerling, A. L. and B. P. Bryant, 2008: "Climate Change and Wildfire in California," *Climatic Change*, 87: s231-249.
- All reports:
  http://www.climatechange.ca.gov/publications/cat/index.html

# We assume the exposure function acts at the pixel level

$$X(H_{pix}s(H_{pix})) = H_{pix}A_s\left[s(d,k))\right]^{-I}\max\left(s(d,k)),0\right)$$

$$s(d,k) = \left[1-\left(\frac{H_{pix}}{d}\right)^k\right]^{1/k}$$

**$A_s$=Area under function *s***

***d* = threshold density for "too-urban-to-burn"**

***k* = shape parameter**

***I* = normalization indicator**